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DETERMINATION
OF
RUMBLE STRIP EFFECTIVENESS

Project HR-184

Final Report

by

Shyamal Basu

Conducted by
Office of Road Design
Highway Division
Iowa Department of Transportation
Ames, Iowa 50010
(515) 296-1392

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ABSTRACT

Rumble strips are patches of specially treated pavement surfaces which are designed to produce aural and tactile stimuli inside vehicles. The intent is to alert drivers and when desirable, cause them to slow down or come to a stop. Installations were made in a three-county area in Iowa to study rumble strip effectiveness as an accident reducing measure. The investigation of accidents at the various test sites showed that rumble strips were effective in reducing certain types of intersection accidents. Although no statistically significant effect of the 'saturation' use was found on total accidents, there are indications that accidents may be reduced when used in low density i.e., rural type areas.

INTRODUCTION

Problem Statement

A considerable percentage of accidents at intersections are of the type where one or more of the drivers fail to stop at the stop sign. Both human and environmental factors may be contributing causes for most of these accidents. Unfamiliarity with the area, poor sight distance, inclement weather are examples of some of the factors. Rumble strips, a device to alert drivers by noise created by vehicle tires on specially treated pavement surfaces, are thought to be one of the appropriate solutions to the above mentioned accident problems. A rumble strip can consist of sawed grooves in the pavement, a series of transverse sprayed thermoplastic strips, or some other means of creating the 'rumble' effect. The Iowa Department of Transportation has been using a pattern of grooved sections cut in the pavement surface in advance of stop controls as shown in Appendix A, at a limited number of selected intersections as depicted in Appendix B. Some counties have adopted a similar program.

In addition to the benefits that may be obtained from accident reductions as a result of rumble strip installations, the effects of 'saturation' use of rumble strips on the total 'ran stop sign' type accidents were studied.

Objectives

The purpose of the research was to identify the effectiveness

of the rumble strip as a traffic safety device when used on a widespread basis in both rural and urban situations. Further, with installations at many types of intersections involving varying geometric and operational characteristics, the effect on total intersection related accidents in the three counties that participated in the above program could be analyzed.

Procedure

The rumble strips were cut by Iowa D.O.T. Maintenance personnel at all rural paved intersections in a three county area at which a stop condition existed and where the pavement design permitted. Locations included Primary to Primary, Primary to Secondary, and Secondary to Secondary highway intersections. Black Hawk, Bremer and Chickasaw counties participated in this research program. These counties offered the locations desired in that they are adjacent counties, one with urban characteristics, one with rural characteristics, and one with an intermediate environment.

All of the rumble strip sections were cut in a manner similar to the standard depicted in Appendix A. The locations where rumble strips were placed in 1976 are shown on the county maps and listings in Appendix B.

The analysis and evaluation of the program considers changes in the number and severity of accidents at intersections which had rumble strips placed. In addition, accidents at all intersections in the 'before' and 'after' period for Bremer and

Chickasaw Counties were compared with similar data for adjacent counties. Due to the unique characteristics of Black Hawk County in that area, its accident data could not be meaningfully compared with any other county.

The effectiveness of rumble strips as an accident reduction measure was studied by comparing 1975 accidents as the 'before' data with 1977 accidents as the 'after' data. For the second part of the study, i.e., the effect of the 'saturation use' of rumble strips on intersection accidents, the 'before' period used was from January 1, 1974 through June 30, 1975 while the 'after' period was from January 1, 1977 through June 30, 1978.

DISCUSSION

As previously stated, rumble strips were cut at all paved intersections at which a stop condition existed and where the pavement design permitted in Chickasaw, Bremer and Black Hawk Counties. These locations included Primary to Primary, Primary to Secondary and Secondary to Secondary highway intersections. The accident data for all three categories of intersections mentioned above were combined as there were no recognized differences among these locations and also because of low frequencies in the total accident occurrence.

In the first part, an evaluation is made of the effect rumble strips have on the number of accidents at locations receiving rumble strips as part of this evaluation program. As the accident reduction capability of rumble strips was studied in this part, only those locations that had previous accident experience were considered. Table I shows the 'before' and 'after' accidents at the above locations by severity class, i.e., property damage, nonfatal injury and fatal types. However, the total number of accidents, only, does not reflect differences in severities. Therefore, a method of weighting the accidents based on severities is needed. This is commonly done by assigning weights of 1, 3 and 12 to property damage, nonfatal injury, and the fatal accidents respectively. As shown in Table I, the total severity points are evaluated based on the above weighting factors. Table I also shows

TABLE I

'BEFORE' AND 'AFTER' ACCIDENTS FOR SELECTED LOCATIONS

BEFORE PERIOD

County	S E V E R I T Y			Total	Rumble Strip Related	Severity Points•
	Fatal	Injury	Property Damage			
Black Hawk	1	17	21	39	8	84
Bremer	0	5	3	8	2	18
Chickasaw	0	9	13	22	7	40
Total	1	31	37	69	17	142

AFTER PERIOD

Black Hawk	1	13	19	33	2	70
Bremer	0	4	5	9	1	17
Chickasaw	0	1	1	2	0	4
TOTAL	1	18	25	44	3	91

PERCENT CHANGE

Black Hawk	0	23.5	9.5	15.4	75.0*	16.7
Bremer	0	20	-66.6	-12.5	50.0	5.6
Chickasaw	0	88.9*	92.3*	90.9*	100.0*	90.0
Total	0	41.9	32.4	36.2*	82.4*	35.9

• Fatal = 12, Injury = 3, Property Damage = 1

* Denotes statistically significant change

that positive reduction in total accidents for all three counties combined occurred in all but the fatal category where there was no change.

A rumble strip related accident is defined, for purposes of this study, as an accident which could be directly influenced by rumble strips. These accidents would involve at least one driver on the rumble strip leg of the intersection who is unaware of the stop control situation and the impending hazard.

Positive reductions occurred in rumble strip related accidents in each of the three counties as shown in Table I. The reductions for Black Hawk County (urban type) and Chickasaw County (rural type) are statistically significant at the 95% level of confidence using the Chi-square test of significance. The Chi-square test is a 'conservative test' which minimizes the chance of calling a reduction significant when it is not.¹ Statistically significant reductions occurred in Chickasaw County for total injury, total property damage and overall total accidents. Statistically significant reductions also occurred for the combined total for all accidents in the three counties and also for the combined total for all rumble strip related accidents. The reductions in the total injury and property damage accidents were significant by the 'liberal' test using the Poisson distribution but failed the Chi-square or the 'conservative' test.¹

¹R. M. Michaels, "Two Simple Techniques for Determining the Significance of Accident Reducing Measures". Traffic Engineering, September, 1966.

A random check on the 'before' and 'after' traffic volumes at the various intersections revealed the change to be quite small. This fact is quite helpful in the 'before' and 'after' comparison, as it has been established by a study that marked differences in traffic volumes do affect the accident experience.²

²"The Interstate Highway Accident Study by Morton S. Raff", Highway Research Board Bulletin 74, 1955, pp 18-45.

'SATURATED' vs. 'CONTROLLED' CONDITIONS

The total intersection related accidents for the 'saturated' counties, i.e., Black Hawk, Bremer and Chickasaw are shown in Table II. The intersection accidents that involve 'stop sign' conditions are shown in Table III. These latter type accidents would be the ones expected to be affected by rumble strip installations. A comparison of the 'before' and 'after' accidents in Tables II and III shows that while total accidents in Bremer County (intermediate type) increased somewhat and a small reduction occurred in Chickasaw County (rural type), stop sign related accidents i.e., those that could be influenced by rumble strips, were reduced considerably. These changes, however, are not statistically significant at the 95% confidence level. In Black Hawk County (urban type), the accidents increased in both total number and 'stop sign' related types. The increases have been statistically significant for total injury and also for the 'stop sign' related injury accidents. However, the 'stop sign' related accidents as a percent of total accidents changed from 23.7% in the 'before' to 29.6% in the 'after' period which is not that pronounced. It seems like in urban areas, high volumes of traffic, resulting in delay and congestion in some cases, is a contributing factor in accident occurrences.

In order to evaluate the effect of the 'saturated' condition on accidents, two other counties, one for rural type (Floyd) and one for intermediate type (Butler) were selected as 'controlled' areas, to compare with Chickasaw and Bremer Counties. No comparable county for Black Hawk was found in the area.

Table IV shows the total accidents and Table V shows the accidents that were related to stop signs. As it is shown in Table IV, the total accidents decreased 7.3% in both Floyd and Butler Counties.

TABLE II

TOTAL INTERSECTION ACCIDENTS FOR 'SATURATED' CONDITION

BEFORE PERIOD

County	S E V E R I T Y			Total	Night	Percent Night
	Fatal	Injury	Property Damage			
Black Hawk	4	40	70	114	29	25.4
Bremer	1	28	36	65	22	33.8
Chickasaw	0	19	21	40	14	35.0

AFTER PERIOD

Black Hawk	3	63	69	135	30	22.2
Bremer	1	32	46	79	23	29.1
Chickasaw	2	13	19	34	8	23.5

PERCENT CHANGE

Black Hawk	25	-57.5*	1.4	-18.4	-3.4	
Bremer	0	-14.3	-27.8	-21.5	-4.5	
Chickasaw	-	31.6	9.5	15.0	42.9	

Minus sign indicates increase

* Indicates statistically significant change

TABLE III

STOP SIGN RELATED ACCIDENTS FOR 'SATURATED' CONDITION

BEFORE PERIOD

County	S E V E R I T Y			Total	Night	Percent Night
	Fatal	Injury	Property Damage			
Black Hawk	2	9	16	27	3	11.1
Bremer	1	10	6	17	6	35.3
Chickasaw	0	6	8	14	3	21.4

AFTER PERIOD

Black Hawk	1	21	18	40	4	10.0
Bremer	0	5	7	12	1	8.3
Chickasaw	0	3	3	6	2	33.3

PERCENT CHANGE

Black Hawk	50	-133.3*	-12.5	-48.1	-33.3	-
Bremer	100	50.0	-16.7	29.4	83.3	-
Chickasaw	-	50.0	62.5	57.1	33.3	-

Minus sign indicates increase

* Indicates statistically significant change

TABLE IV

TOTAL INTERSECTION ACCIDENTS FOR 'CONTROLLED' CONDITION

BEFORE PERIOD

County	S E V E R I T Y			Total	Night	Percent Night
	Fatal	Injury	Property Damage			
Butler	1	24	30	55	14	25.5
Floyd	0	27	28	55	15	27.3

AFTER PERIOD

Butler	0	18	33	51	13	25.5
Floyd	0	28	23	51	22	43.1

PERCENT CHANGE

Butler	100.0	25.0	-10.0	7.3	7.2	-
Floyd	0	-3.7	17.9	7.3	-13.4	-

Minus sign indicates increase

TABLE V

STOP SIGN RELATED ACCIDENTS FOR 'CONTROLLED' CONDITION

BEFORE PERIOD

County	S E V E R I T Y			Total	Night	Percent Night
	Fatal	Injury	Property Damage			
Butler	1	6	5	12	6	50
Floyd	0	7	5	12	2	16.7

AFTER PERIOD

Butler	0	3	2	5	0	0
Floyd	0	10	2	12	3	25

PERCENT CHANGE

Butler	100	50	60	58.3	100	-
Floyd	-	-42.9	60	0	-50	-

Minus sign indicates increase

In comparison, Table V shows no reduction in the stop sign related accidents for Floyd County but does show a large reduction for Butler County. However, if the normal trends in accident occurrence (i.e., decrease of 7.3%) for these counties are taken into account and adjustments made accordingly, the reduction for Butler County will be less observable and for Floyd there will actually be an increase. Also, none of the changes were statistically significant at the 95% level using the Chi-square test for significance.

Examining the severity of the accidents, the personal injury accidents for Floyd County have increased nearly 43% for stop sign related accidents although the injury accidents for all intersections in Floyd County increased only 3.7% in the same period.

Nighttime Accidents

It was felt that installation of rumble strips might be effective during nighttime conditions as an accident reduction measure. Thus a comparison was made between the 'saturated' and the 'controlled' counties on the 'before' and 'after' nighttime accidents. As seen in Table II, the percent nighttime accidents for the total intersection accidents did not show any marked change for the 'saturated' counties. However, as shown in Table III, the percent nighttime accidents for the stop sign related accidents only, in the same counties, did show a considerable reduction for Bremer County (intermediate type) and an increase for Chickasaw County (rural type). A very small change occurred for Black Hawk County.

It seems apparent from the above findings that this study did not establish any significant correlation between the existence of rumble strips and the frequency of nighttime accidents at an intersection.

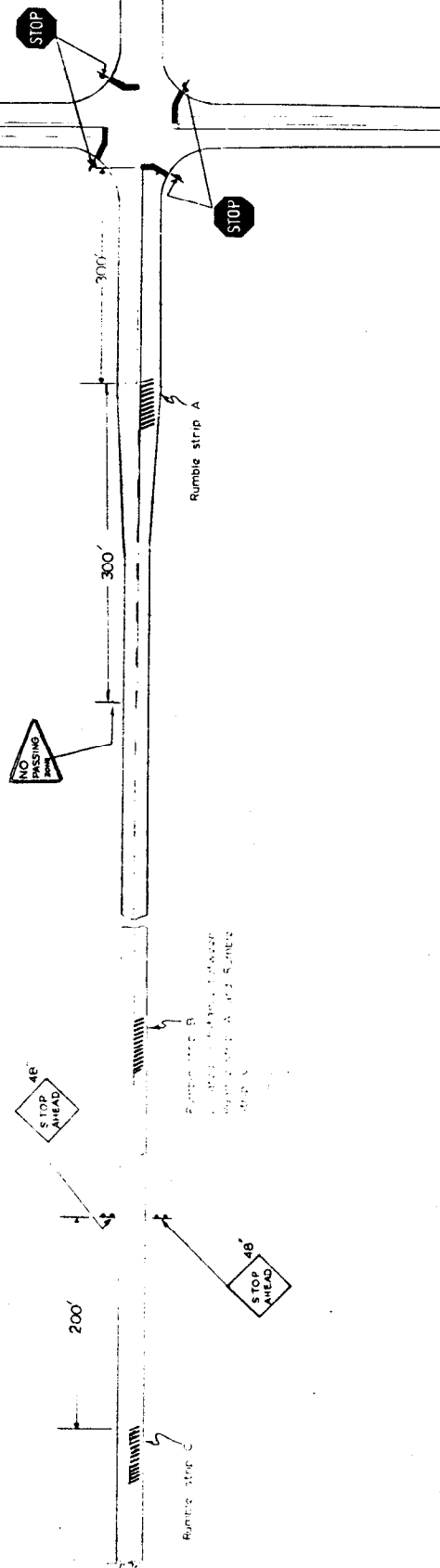
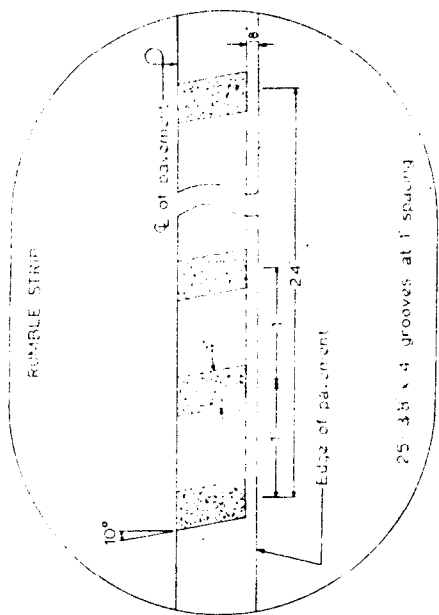
CONCLUSIONS AND DISCUSSION

The results of the study show that there is evidence of accident reductions on approaches to intersections that have a history of 'ran stop sign' type accidents. This can be interpreted to mean that drivers have been made more aware of the hazard ahead by the rumble strips. The benefit of such an aural stimulus is exemplified by the accident reports in Appendix D. In the first report, the driver who ran the stop sign in Chickasaw County told witnesses that he did not see the sign at all. In the other accident report, which occurred in a rural section of Pottawattamie County, the driver at fault stated that he thought the stop sign was located about three miles on down the road. Thus, the results of this study would justify recommending the installation of rumble strips for locations experiencing 'ran stop sign' type accidents.

The 'saturation use' of rumble strips, which makes up the second part of this study, did not seem to have any significant effect on the occurrences of all types of accidents in the intermediate type and urban type counties. In the rural type county, however, the results have indicated positive overall reductions of accidents. In rural areas, with low traffic volumes and relatively large distances between intersecting roads, the rumble strip should be helpful in alerting unsuspecting motorists as indicated in the accident reports in Appendix D. In a more developed area, factors other than the lack of awareness of hazards,

seem to be predominant. Though it is not possible to conclude definitely from this data alone, that the 'saturated' use had an effect on the accidents, it is apparent from the results of this study, that the greatest benefit of this type of use can be derived from areas of low densities and low traffic volumes.

Appendix A



RUMBLE STRIP STANDARD

Appendix A

DIAGRAM WHAT HAPPENED:

INSTRUCTIONS

Follow dotted lines to draw outline of roadway at place of accident.

Number each vehicle and show direction of travel by arrow.



Use solid line to show path before accident.



dotted line after accident



Show pedestrian by: —○

Show railroad by: ++++++

Show utility poles by: φ

Show motorcycle by: ⊙—⊙

Show animal by: ♂

INDICATE NORTH



INITIAL DIRECTION TRAVEL

Veh 1	Veh 2	Veh 3	Veh 4
5	3		
1=North	2=Northeast	3=East	4=Southeast
5=South	6=Southwest	7=West	8=Northwest
		0=Unknown	

DESCRIBE WHAT HAPPENED (Refer to vehicles by number)

Vehicle #2 was eastbound on #6 and Vehicle #1 was southbound on the county road.

Vehicle #1 ran the stop sign and ran into the side of Vehicle #2 as it was going by the intersection. Driver #1 stated he thought the stop sign was about 3 miles or so away yet and wasn't even thinking about having to stop until he was going by the stop sign.

Name, Last, First	Street or RFD	City	State	Zip

Driver No.	Citation No.	Statute No.	Charge	Violation of: State Code City Ordn	Recommend DL Reexam Yes No	Vehicle to be Inspected Yes No
1	BL18553	321.322	Stop sign	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Was Investigation Made at Scene? ☒ 1 Yes ☐ 2 No Investigation Completed? ☒ 1 Yes ☐ 2 No Police Photos Taken at Scene? ☒ 1 Yes ☐ 2 No Reports Given To All Drivers ☒ 1 Yes ☐ 2 No

This Location Needs: ☒ 1 Selective Enforcement ☐ 2 Engineering Study ☐ 3 Road Maintenance ☐ 4 Other ☐ 5 No Recommendation

OFFICER COMMENTS CONCERNING LOCATION NEEDS

Time Officer Notified of Accident 9:32 ☒ A.M. ☐ P.M. 10-8-75

Time Officer Arrived At Scene 9:50 ☒ A.M. ☐ P.M. 10-8-75

Signature of Officer C. W. Clark Badge No. 55

Name of Department Public Safety Date of Report 10-8-75

Report Reviewed by *[Signature]* Date Reviewed 10-22-75